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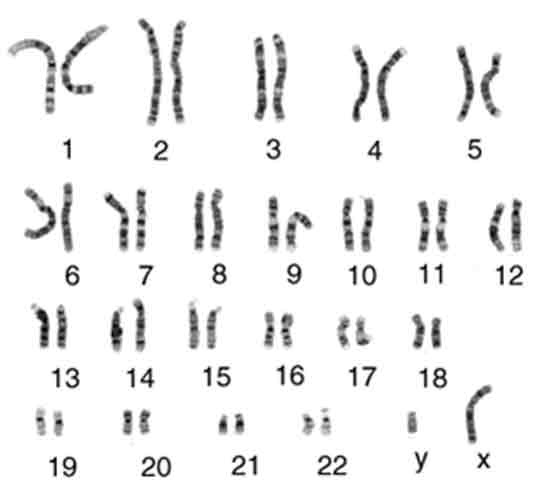
**Unit 5 Notes, Part 2: Meiosis**

Mrs. Krouse, AP Biology

**You do NOT need to do annotations for these notes!**

**New Vocabulary**

1) Mitosis is the process of creating new body cells (somatic cells). These cells have two full sets of chromosomes, so we consider them diploid (2n). One set of chromosomes comes from Mom (maternal) and one set of chromosomes comes from Dad (paternal). In humans, one set of chromosomes consists of 23 chromosomes, so two sets of chromosomes consists of 46 chromosomes.

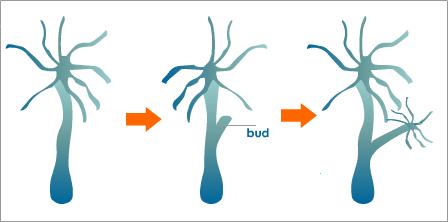
2) Meiosis is the process of creating new sex cells (gametes). These cells have only one set of chromosomes, so we consider them haploid (n).

3) A karyotype is an image that allows us to see all the chromosomes in a human body cell. Human body cells have 46 chromosomes (arranged in a karyotype as 23 pairs), and human sex cells have 23 chromosomes.

4) Human body cells have two sex chromosomes (X or Y). The female combination of sex chromosomes is XX, and the male combination of sex chromosomes is XY.

5) The remaining 44 chromosomes in a human body cell are called autosomes, which means they are non-sex chromosomes and control regular body traits that are found in both males and females. In a cell, these chromosomes are paired up. These pairs of chromosomes are called homologous chromosomes. You received one chromosome in each pair from your mother and one for your father. Homologous chromosomes have the same length, centromere position, and genes controlling the same inherited characteristics. For example, let’s say a pair of homologous chromosomes have the eye color gene in the same location. Perhaps one chromosome has the eye color gene variation that codes for brown eyes and the other has the eye color gene variation that codes for blue eyes.

6) Mitosis can be involved in asexual reproduction, the creation of genetically identical offspring (clones) from a single parent. An example of this process occurs in hydra and is called budding (see image below).



7) Meiosis can be involved in sexual reproduction, the creation of genetically different offspring from two parents.

8) Meiosis in humans produces sperm and egg cells with 23 chromosomes. During fertilization, one sperm meets up with one egg to create a zygote (aka fertilized egg) with 46 chromosomes. This zygote is considered diploid because it has two sets of chromosomes. This diploid zygote can divide by mitosis to create body cells in the new baby with 46 chromosomes each.

9) **Question:** Why must the chromosome number in gametes be half the chromosome number in somatic cells?

**Side-By-Side Comparison of Mitosis and Meiosis**

|  |  |  |
| --- | --- | --- |
| **Characteristic** | **Mitosis** | **Meiosis** |
| Goal | Making new body cells (somatic cells) for asexual reproduction (in some organisms), growth, and replacement of dead cells | Making sex cells (gametes) for sexual reproduction |
| Daughter Cells | Two diploid cells (2n) that are genetically identical to the parent cell | Four haploid cells (n) that are genetically different from the parent cell and each other |
| # of Divisions | One | Two (meiosis I and II) |
| Location | In all body cells | In the gonads (ovaries or testes) |
| Picture | mitos diagram | meio diagram |

**Preparing for Meiosis**

10) Before meiosis, the parent cell must go through all the stages of interphase (see mitosis notes) and must duplicate its DNA.

11) DNA replication occurs during the S (synthesis) phase of interphase.

12) Once a cell has completed the G2 phase, it can begin meiosis.

**Meiosis I**

|  |  |  |
| --- | --- | --- |
| **Stage Name** | **Description** | **Picture** |
| Starting Materials | * One diploid parent cell |  |
| Prophase I | * Synapsis occurs. Synapsis is the pairing of homologous chromosomes. * A pair of homologous chromosomes is called a tetrad (because it is a group of four sister chromatids) * Synapsis allows for crossing over. Crossing over is also called genetic recombination and it involves the exchange of DNA between homologous chromosomes within a pair. * Chiasma (pl. chiasmata) = regions where crossing over is taking place * The nuclear envelope and nucleolus break down * The mitotic spindle forms and centrosomes move towards the poles of the cell |  |
| Metaphase I | * Kinetochores connect to mitotic spindle fibers (Technically, this occurs during Prometaphase I) * Homologous pairs line up at the metaphase plate |  |
| Anaphase I | * Homologous chromosomes separate (chromatids on a single chromosome DO NOT separate yet) * Segregation = separation of homologous partners to different daughter cells * Independent Assortment = mixing of paternal and maternal chromosomes in different combinations… each chromosome pair lines up differently / independently along the metaphase plate |  |
| Telophase I | * Some (but not all) organisms’ nuclear envelopes reform and chromosomes unwind into chromatin before the second division |  |
| Cytokinesis I | * The cytoplasm divides | See picture above of the cleavage furrow forming in the dividing animal cell |
| Product | * Two haploid cells (1n), each with chromosomes that have two chromatids (identical copies of DNA) | See picture above |

*Note: I have left out prometaphase, but you should assume that all the events that occur in prometaphase of mitosis occur in prometaphase I and II of meiosis as well!*

13) In some organisms, the daughter cells of meiosis I enter a brief period of rest before meiosis II. Some sources refer to this as a second interphase, or they call it “interkinesis.” It is less accurate to call it a second interphase because the DNA is not copied again (so some of the events that happen in the interphase before Meiosis I do not occur in this “interkinesis” between meiosis I and meiosis II).

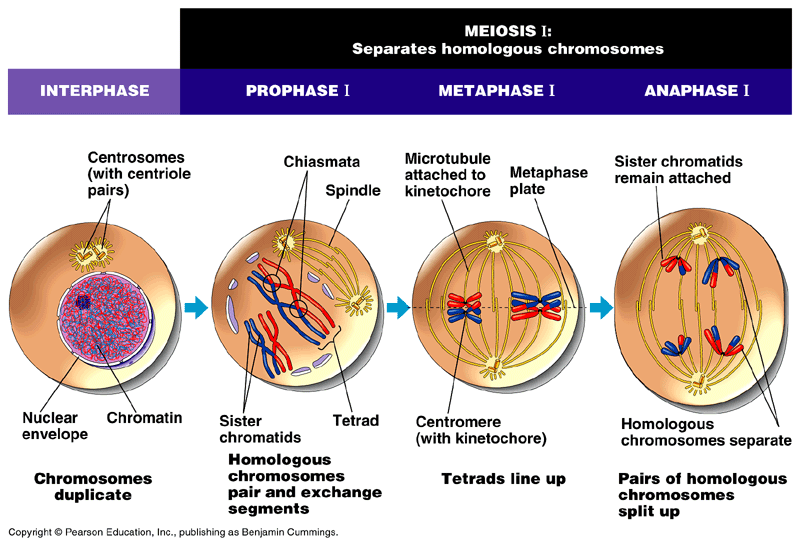
**Meiosis II**

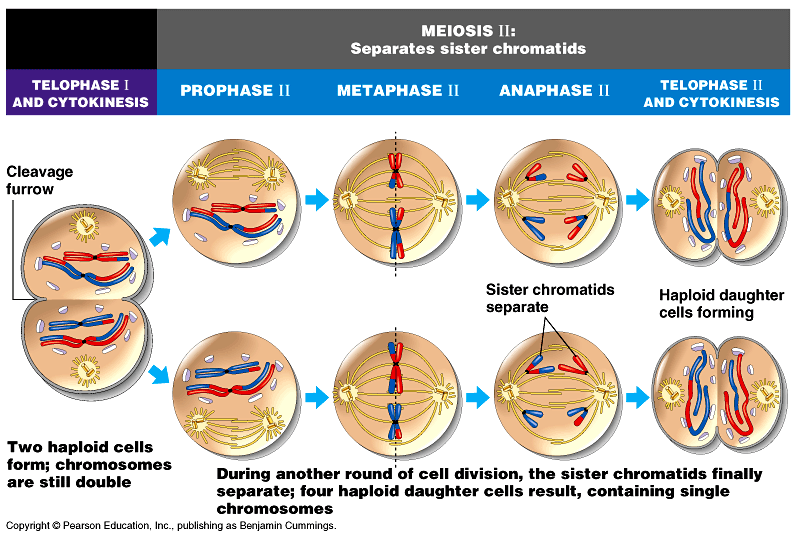
|  |  |  |
| --- | --- | --- |
| **Stage Name** | **Description** | **Picture** |
| Starting Materials | * Two haploid cells, each with chromosomes that have two chromatids (identical copies of DNA)… the products of Meiosis I ☺ | No picture, sorry! |
| Prophase II | * If chromosomes unwound after Meiosis I, they wind back up again * If the nuclear envelope reformed after Meiosis I, it breaks down again * If the mitotic spindle has broken down after Meiosis I, it is reformed * Centrosomes move to opposite poles of the cell | Assume this happens twice (once with each of the starting cells) |
| Metaphase II | * Kinetochores connect to mitotic spindle fibers (Technically, this occurs during Prometaphase II) * Chromosomes line up SINGLE FILE along the metaphase plate | Assume this happens twice (once with each of the starting cells) |
| Anaphase II | * Chromosomes separate into two sister chromatids that move to opposite ends of the dividing cell | Assume this happens twice (once with each of the starting cells) |
| Telophase II | * The nuclear envelope reforms * Chromosomes unwind into chromatin * The mitotic spindle breaks down | Assume this happens twice (once with each of the starting cells) |
| Cytokinesis II | * The cytoplasm divides | See picture above |
| Product | * Four haploid cells (“1n” or just “n”), each with chromosomes that have only one chromatid * These cells are considered gametes (ex: sperm and egg). They are the final products of meiosis |  |

*Note: I have left out prometaphase, but you should assume that this occurs as well!*

14) Remember, the DNA is NOT copied again between meiosis I and meiosis II!

15) **Question:** What are the main differences between Meiosis I and Meiosis II?





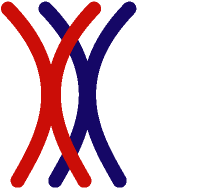
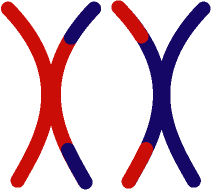
16) **Question:** Which process is most similar to mitosis – Meiosis I or Meiosis II? Why?

**Advantages of Sexual Reproduction**

17) Sexual reproduction produces offspring that are genetically different from the parents; this creates genetic variation within a population of organisms and makes the population less susceptible to extinction due to environmental stressors (ex: a disease may only wipe out organisms with a particular gene).

18) Three ways that meiosis produces genetic variation

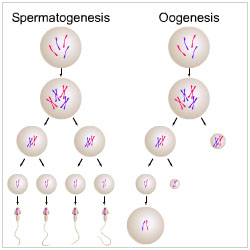
* Variation from crossing over: mixing of genes between homologous chromosomes… creates an INFINITE variety of possible genetic combinations



**tetrad**

**synapsis**

* Variation from independent assortment of chromosomes: random alignment of homologous chromosomes along the metaphase plate during Metaphase I… independent assortment in humans produces 223 (8,388,608) different combinations in gametes
* Variation from random fertlization: which sperm fertilizes which egg?... any two parents (who each produce MANY gametes throughout the course of their lifetimes) will produce a zygote with over 70 trillion (223 x 223) possible diploid combinations (and this doesn’t even take into account crossing over!)

**Meiosis in Humans**

18) **Spermatogenesis**: the process of creating male gametes (sperm); meiosis produces four haploid cells; maturation adds tails 🡪 four functional sperm; Occurs in the testes (singular: testis)

19) **Oogenesis:** the process of creating female gametes (eggs or ova); the cytoplasm divides unevenly and produces one egg (lots of cytoplasm) and three polar bodies (have DNA but very little cytoplasm) ; the polar bodies later degenerate ; this process gives the egg the best start with all the resources it needs; Occurs in the ovaries

**Notes Questions**

For each of the statements, write a yes or a no to indicate specific differences between **Mitosis and Meiosis I:**

|  |  |  |
| --- | --- | --- |
| **Statement** | **Mitosis** | **Meiosis I** |
| During interphase, do DNA and other organelles replicate? |  |  |
| During prophase, does crossing over occur? |  |  |
| During metaphase, do the homologous chromosomes pair-up together? |  |  |
| During anaphase, do the sister chromatids separate? |  |  |
| During anaphase do the homologous pairs separate from each other? |  |  |
| Are the cells at the end diploid or haploid? |  |  |

For each of the statements, write a yes or a no to indicate specific differences between **Mitosis and Meiosis II:**

|  |  |  |
| --- | --- | --- |
| **Statement** | **Mitosis** | **Meiosis II** |
| Does crossing over occur? |  |  |
| During anaphase, do the sister chromatids separate? |  |  |
| Are the cells at the end diploid or haploid? |  |  |

For each of the statements, write a I or II to indicate whether this statement applies to **Meiosis I or Meiosis II.**

|  |  |
| --- | --- |
| **Statement** | **I or II?** |
| The end result of this process is four daughter cells. |  |
| The end result of this process is two daughter cells. |  |
| This process is similar to mitosis. |  |
| This process converts a parent diploid cell to haploid daughter cells. |  |
| This process converts a parent haploid cell to haploid daughter cells. |  |
| Chromosomes line up single file along the metaphase plate. |  |
| Chromosomes line up in homologous pairs along the metaphase plate. |  |
| Synapsis (pairing of homologous chromosomes) and crossing over take place. |  |
| Spindle fibers separate chromatids at the centromere. |  |
| Spindle fibers separate pairs of homologous chromosomes. |  |

1. Compare and contrast metaphase I and metaphase II of meiosis.

1. Compare and contrast anaphase I and anaphase II of meiosis.
2. Compare and contrast the daughter cells of mitosis vs. meiosis. (Ex: Are they diploid or haploid? What type of cells are they? How many daughter cells are formed? Are the daughter cells genetically identical?)
3. What is crossing over? Why is it important for maintaining genetic variation in a population?
4. Let’s say an egg cell has 18 chromosomes. How many chromosomes did the original parent cell contain? Explain your reasoning.
5. Why do polar bodies form during oogenesis (meiosis in human females)? Why don’t polar bodies form during spermatogenesis (meiosis in human males)?
6. How many functional eggs are created during one round of oogenesis? How many functional sperm are created during one round of spermatogenesis?